CHAPTER 5

ENGINEER CONSIDERATIONS PERTAINING TO CONSTRUCTION

5-1. General. The safety and performance of sheet pile cellular structures are very sensitive to site conditions and construction practices. This is particularly true for cellular cofferdams since many failures have been attributed to site conditions or construction practices, the effects of which were not properly taken into account in the design. Great care must be taken to ensure that the effects resulting from all potential construction and in-service site conditions, and construction techniques, are properly anticipated, considered, and accounted for in the design. In addition, construction progress must be closely monitored by design personnel in order to evaluate or verify design assumptions and to recognize any changed conditions which might require a design modification.

5-2. Failures.

a. Failure Modes. The primary reported causes of cofferdam failures are:

(1) Structural.

(a) Fabricated Tees and Wyes. Numerous failures have involved welded connector piles. Such failures in welded tees normally occurred in the web of the main sheet pile, the web often rupturing on both sides of the tee stem and separating the tee into three pieces. Weakness in these tee members is attributed to improper welding of steel with a high carbon content and laminations in the steel sheet piles used in fabricating the tees.

(b) Sheets and Interlocks. Interlock failure has resulted primarily from hard driving through dense or excessively deep overburden, overburden containing boulders, or from attempting to drive sheets of the connecting arcs past distortions in previously filled main cells. Splicing new and used sheet piling of different manufacturers has resulted in unpredictably high localized stresses in the interlocks and in the webs of sheets with resulting failure.

(2) Environmental Conditions. Scour and other effects of river currents have contributed to a number of cofferdam failures. Where the overburden is susceptible to erosion, scour due to high velocity flow is a serious problem. By removing the lateral support provided by the overburden interlock, stresses have increased. Where driving through the overburden was difficult, some sheets have not penetrated to rock or have been driven out of interlock. Continued scour exposed these deficiencies and resulted in loss of cell fill and subsequent failure. High water has contributed to several failures by raising the level of saturation in the cell fill thus increasing interlock stresses.

(3) Stability.

(a) Soil Mechanics. Cofferdams built in accordance with current design practice have generally proved adequate as far as the soil mechanics aspects of the design are concerned. However, there is the exception of piping failures at cofferdam cells tying into existing structures or into high ground. In these cases, failures have resulted from loss of cell fill due to piping caused by inadequate provision for seepage control.

(b) Foundations. A few cofferdam failures have occurred because of foundation failure well below the base of the cells. This mode of failure has been precipitated by faults, slip planes, or high uplift pressures not recognized as problems during design. Also, foundation failure has occurred because of excavations located too near the cofferdam cells which allowed stress relief and relaxation of the rock.

(4) Saturation of Cell Fill. Saturation of the cell fill is associated with many failures. The pressure of the water when added to the lateral pressure of the cell fill increases the interlock stresses. The saturation of the fill in the connecting arc is a particularly potent danger because of the magnitude of the tension that can be created on the outstanding leg of a connector. It should be noted that saturation can be caused by means other than the common leakage through the interlocks, holes, splices, and filling by the hydraulic dredge method. Waves splashing over the top of the cells, leakage, or breaks in the discharge lines of unwatering pumps over the cells can quickly cause saturation of the fill.

(5) Construction Practices. A number of failures have occurred during construction of cofferdams which may have been attributable, in part, to construction practices. Unless the sheet piling is driven in overburden, the lateral stability of the cell is largely dependent on the support furnished by the template until fill is placed in the cell. If this support is inadequate or the filling operations impose severe loads on the sheet piles, local distortion or collapse may occur. The practice of driving sheet piles in pairs may be detrimental if the bedrock is uneven. Windows or split interlocks can occur with possible loss of cell fill and subsequent failure. Therefore, when piles are driven in pairs, the sheets should be seated in rock individually.

b. Conclusions. Based on available information, as summarized above, the following conclusions can be drawn:

(1) Current soil mechanics design practices are adequate to produce a stable cell. Analytical methods for investigating foundation stability also appear to be satisfactory. Reported failures due to foundation failure have generally resulted from a failure to recognize potential failure planes or when recognized, failure to assign realistic strengths to such planes.

(2) Saturation of the cell fill is present in a large number of cofferdam failures.

(3) Structural failure of 90-degree welded tees has been the most prevalent cause of cofferdam failure.

(4) Scour due to high velocity flow is a common cause of cofferdam failure.

5-3. Recommended Practices. The following recommendations regarding design, construction, and maintenance of cellular sheet pile cofferdams have already been discussed in preceding chapters. However, their importance should again be stressed.

a. Analyses should evaluate the effect of full saturation of the cell fill unless positive measures are taken to control the saturation level throughout the life of the cofferdam.

b. Welded connector piles have not proven satisfactory in the past and shall no longer be used. Riveted or bolted connections with minimum 1/2-inch thick webs shall be required.

c. Wye connectors are preferable to tees. The tension in the outstanding leg of the connector is less for a wye since the load is applied more nearly tangent, rather than at right angles, as is the case with a tee.

d. Pull on the outstanding leg of connector piles should be limited by keeping the radius of the connecting arc as small as possible. The arc radius should not exceed one half of the radius of the main cell.

e. Where there is used piling in a cofferdam, care should be taken to make sure the sheets are gaged and will interlock properly. Special care should be taken in splicing used sheets to make sure the spliced sheets are compatible.

f. All handling holes in the sheet piling on the loaded side of the cofferdam should be plugged. This is necessary to prevent an objectionable amount of water from entering the cell or loss of cell fill.

g. Sheet piling should not be driven through overburden containing boulders. Extremely dense overburden should be excavated to a depth such that it can be penetrated without damaging the piling. Although dependent on the nature of the overburden, 30 feet is generally accepted as a maximum depth to drive through overburden.

h. When driving is difficult, jetting may be used to facilitate driving. However, this technique should be used with caution since there is a danger that the sheet piles will follow the jetted hole and will split out the interlock.

i. If it is not possible nor practical to fully penetrate the overburden with the sheet piles and if scour by river flow is a possibility, the overburden should be protected against scour.

j. Setting sheet piling on bare rock should be avoided wherever possible since support from the overburden is beneficial in helping maintain the desired cell configuration.

k. Each run of piling shall be driven to grade progressively from the start, so that the bottom end of any pile shall not lead the adjacent pile by more than 5 feet. This requirement will reduce the chances of splitting the interlocks.

l. The direction of the pile hammer advance should be reversed after each pass in order to ensure that the piles are driven plumb.

m. Connecting arcs should be driven and filled after the adjacent main cells have been driven and filled. However, at least the first two sheets of the connecting arc adjacent to the main cells should be driven prior to filling the main cells; otherwise, barrelling of the main cells would make driving of the arcs extremely difficult.

n. Diver inspection of the interlocks, after filling of the cells, should be required.

o. Wherever cells and fill are placed against sloped or stepped faces of existing concrete, care should be taken to seal the contact between the sheet piles and concrete to prevent infiltration of water which could saturate the fill or cause piping.

p. The cofferdam cells should be located a sufficient distance from open excavations to protect them from any instability of the excavated faces.